# UCAR Visiting Scientist Program at the National Ice Center

Meg Austin
University Corporation for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307-3000
Phone: 303-497-8630 Fax: 303-497-8668
E-mail: austin@ucar.edu

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http://www.vsp.ucar.edu
http://www.natice.noaa.gov

## LONG TERM GOALS

The long-term goal of the University Corporation for Atmospheric Research (UCAR) Visiting Scientist Program at the National Ice Center (NIC) is to recruit the highest quality visiting scientists in the ice research community for the broad purpose of strengthening the relationship between the operational and research communities in the atmospheric and oceanic sciences.

The University Corporation for Atmospheric Research supports the scientific community by creating, conducting, and coordinating projects that strengthen education and research in the atmospheric, oceanic and earth sciences. UCAR accomplishes this mission by building partnerships that are national or global in scope. The goal of UCAR is to enable researchers and educators to take on issues and activities that require the combined and collaborative capabilities of a broadly engaged scientific community.

## OBJECTIVES

The objectives of the UCAR Visiting Scientist Program at the NIC are:

- Manage a visiting scientist program for the NIC Science Center in support of the mission of UCAR.
- Provide a pool of researchers who will share expertise with the NIC and the science community.
- Facilitate communications between the research and operational communities for the purpose of identifying work ready for validation and transition to an operational environment.
- Act as a focus for interagency cooperation.

The NIC mission is to provide worldwide operational sea ice analyses and forecasts for the armed forces of the U.S. and allied nations, the Departments of Commerce and Transportation, and other U. S. Government and international agencies, and the civil sector. The NIC produces these analyses and forecasts of Arctic, Antarctic, Great Lakes and Chesapeake Bay ice conditions to support customers with global, regional and tactical scale interests. The NIC regularly deploys Naval Ice Center NAVICECEN Ice Reconnaissance personnel to the Arctic and Antarctica in order to perform aerial ice

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14. ABSTRACT
**The long-term goal of the University Corporation for Atmospheric Research (UCAR) Visiting Scientist Program at the National Ice Center (NIC) is to recruit the highest quality visiting scientists in the ice research community for the broad purpose of strengthening the relationship between the operational and research communities in the atmospheric and oceanic sciences.**

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observation and analysis in support of NIC customers. NIC ice data are a key part of the U.S. contribution to international global climate and ocean observing systems.

## APPROACH

The UCAR Visiting Scientist Program works with participating Federal agencies to recruit scientific visitors and recent PhDs who are interested in conducting applications-oriented research and product evaluation of relevance to the NIC ice-monitoring mission. The UCAR visiting scientists are a source of expertise for the NIC as well as mentors to the recent PhDs.

Current participating agency representatives are:

Dr. Waleed Abdalati: NASA program sponsor
Dr. Tony Beesley: UCAR Visiting Scientist
Mr. Michael Chase: Product Development/ Programming Support/Web development
Mr. Phil Hovey: NOAA Physical Science Technician
Dr. Ted Maksym: UCAR Postdoctoral Fellow
Dr. Walt Meier: UCAR Visiting Scientist
Dr. Juanita Sandge: NRL Stennis Space Center program sponsor
Dr. Dharmendra Singh: UCAR Post-Doctoral Fellow – position offered
Dr. Michael VanWoert: NIC Chief Scientist
Dr. Cheng-Zhi Zou: UCAR Visiting Scientist

## WORK COMPLETED

This ONR sponsored activity encompasses two research projects: 1. Operational Modeling of the Marginal Ice Zone, and 2. Data Assimilation. Each research project is described separately.

### *Operational Modeling of the Marginal Ice Zone*

Drs. Leif Toudal of the Denmark Technical University (DTU) and Max Coon of Northwest Research Associates (NWRA) developed a sea ice model (MIZMO) explicitly for use in the marginal ice zone. The basic approach in the model is to move the ice by winds provided by the Naval Operational Global Atmospheric Prediction System (NOGAPS) and currents from the Polar Ice Prediction System (PIPS) under the assumption of free drift. Observed ice concentrations from SSM/I imagery are then compared to model concentrations to provide a measure of ice growth or melt. New ice is apportioned between frazil and pancake ice by a simple parameterization scheme.

MIZMO is now being tested at the NIC with the eventual aim of transitioning to an operational model suitable for assisting in daily ice analysis and forecasting in the marginal ice zone. In addition, the model will be tested during a field campaign aboard the USCGC Healy in the Barents Sea in Oct.-Nov. 2001 (ALTEX).

Work on this project comprises five primary activities:

1. Compilation of model forcing data, facilitation of data ingest and transition to an automated model product.

2. Determination of free drift drag coefficients for driving ice motion.

3. Collections of field data during the ALTEX cruise. This will include routine sea ice observations, measurement of physical properties, and energy fluxes. This will provide critical information for both evaluating model performance and refining model parameterizations.

4. Comparison of model performance with available ice products (OLS, RADARSAT, NIC ice charts) in various marginal seas (e.g. Bering, Barents, Greenland, Weddell, Okhotsk) and tuning to provide an optimal operational product.

5. Comparison of model ice growth/decay with energy flux based prediction to provide a measure of model performance and guidance in model tuning.

The following work has been completed or is underway:

1. The MIZMO model has been installed at NIC and is currently running in test phase. Preliminary testing has confirmed the need for inclusion of spatially varying forcing fields and sheet ice. An improved version of MIZMO will begin testing during the arctic field campaign.

2. Ten months of NOGAPS, PIPS, and SSM/I data have been assembled for driving MIZMO. Determination of the best quality forcing data for use by MIZMO is underway. In addition, 10 months of visible and infrared (OLS) and RADARSAT imagery have been assembled for determination of appropriate drag coefficients and model verification. Computation of drag coefficients for each region of interest is underway.

3. An automated data ingest module has been developed. This will facilitate automated operational use of MIZMO.

***Data Assimilation***

The UCAR Visiting Scientist Program is working with the U.S. Navy in the development of a new version of the Polar Ice Prediction System (PIPS) sea ice forecast model (Preller and Posey, 1989). This model produces forecasts of ice concentration, ice thickness and ice motion for nowcasts and forecasts out to 120 hours. The newer version, PIPS3.0, will employ a higher resolution, more advanced ocean model component, and more sophisticated ice dynamics and ice thickness distribution treatments. Accurate data initialization is crucial for useful forecasts. In the current version (PIPS2.0), daily SSM/I ice extent fields are used for initialization; the model's extent and temperature are adjusted to match the SSM/I field. This, in effect, is a simple forcing of the model with SSM/I data. However, SSM/I data is far from perfect. A more advanced method of using observational data within models is to employ data assimilation techniques. These techniques take into account the distribution and quality of data to obtain optimal fields. The goal of this project is to investigate data assimilation techniques, and implement and test them in the PIPS3.0 model.

Sea ice motion fields were chosen for assimilation for two reasons. First, ice motion is a parameter that is consistent in both the model and observations (both output the same variable - motion). Second, sea ice motion plays a large role in the ice dynamics and thus the evolution of the ice cover.

The following work was completed on this project:

1. Optimal interpolation (OI) assimilation algorithm was delivered to the NPS for testing in the PIPS3 model. The OI method uses error statistics of modeled and observed motions to determine an optimal weighting to obtain improved motion estimates (Meier, 1998; Meier et al., 2000). The OI method was implemented in the PIPS model at NPS and the preliminary results are promising. Results can be viewed at the PIPS Data Assimilation web page: http://www.oc.nps.navy.mil/~stark/assimilation.html

2. An 85 GHz ice-tracking algorithm on the Polar Ice Prediction (PIPS) grid was transitioned in April 2001from the NIC Science Team to Navy Fleet Numerical Center for operational implementation. This product is now providing operational drift vectors to the NIC analysts.

3. PIPS Integrated Product Team meetings were held in November 2000 and June 2001. Individuals gave briefings from the NIC science team, the Naval Post Graduate School, academia, and industry on development of PIPS version 3.0.

4. Sea Polar Ice Prediction System Requirements Specified: Working closely with analysts at the NIC, M. Van Woert and W. Meier translated working level sea ice forecasting guidelines into quantitative requirements for a Polar Ice Prediction (PIPS) sea ice forecasting model and briefed these requirements to the PIPS integrated product development team.

5. PIPS validation studies briefed: In May 2000 T. Beesley, W. Meier, C.Z. Zou and M. Van Woert each presented progress reports on validation studies of PIPS 2.0 as a benchmark for comparison of PIPS 3.0. M. Van Woert study in Monterey June 2001.

## RESULTS

### *Operational Modeling of the Marginal Ice Zone*

MIZMO has been run for the Bering Sea for the winter of 2000-2001 (Figure 1). As expected, frazil ice is dominant in those areas leeward of islands, such as St. Lawrence Island and land masses, such as along the Anadyr coast (Figures 1b and 1c). Although the model produces qualitatively realistic results, several avenues for improvement are apparent. First, the need for spatially varying winds and a method to deal with ice convergence is clearly apparent even in relatively small ice covered regions such as the Bering Sea. Second, the presence of, and transition to sheet ice must be accounted for in the model, both for initializing a model run and for dealing with old ice advected into the model region. This capability, available in the newest version of MIZMO will begin testing in fall of 2001 during the ALTEX cruise of the USCGC Healy.

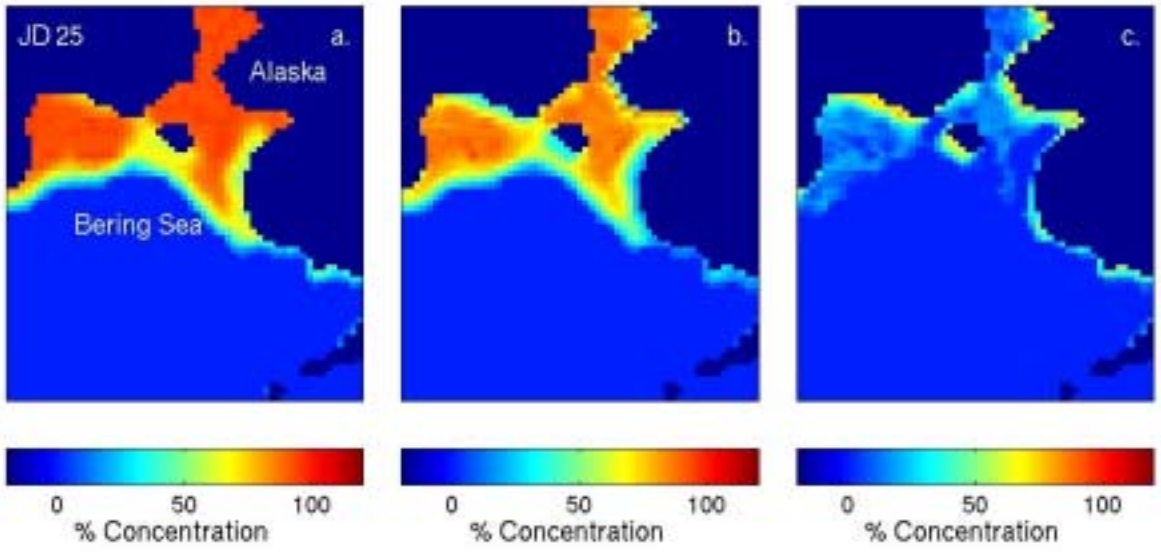


***Figure 1. Example of MIZMO output for the Bering Sea for January 25, 2001. (a) SSM/I ice concentrations used to drive the model, (b) concentration of pancake ice, and (c) concentration of frazil ice. Frazil ice is most apparent leeward of land masses.***

Other areas for improvement include treatment of melting ice, where current SSM/I concentration algorithms tend to underestimate ice extent, and treatment of ice formation near land, where coastal contamination of the SSM/I brightness temperature may lead to inaccuracies in predicted ice formation rates. This is especially important in coastal polynyas.

## IMPACT/APPLICATIONS

### *Operational Modeling of the Marginal Ice Zone*

The primary goal for this project is to transition MIZMO to an operational setting at NIC. This will provide a valuable tool to aid ice analysts in providing accurate determinations of current ice conditions in the regions most important to the customers of NIC, i.e. the marginal seas. Specifically, it is hoped that it can provide an estimate for ice thickness where currently no accurate means are available. The addition of a forecast module to MIZMO will be invaluable in supplementing PIPS ice forecasts with forecasts for the MIZ.

## TRANSITIONS

The NIC science team is now providing the following products to the operations floor in near-real-time.

NIC Hybrid sea ice algorithm (Northern/Southern Hemispheres)

NASA Team Sea Ice algorithm (Northern Hemispheres)

NASA Thin-Team Sea Ice algorithm (Northern/Southern Hemispheres)

NASA Team-2 Sea Ice Algorithm (Northern/Southern Hemispheres)

CAL-VAL sea ice algorithm (Northern/Southern Hemispheres)

Brystol sea ice algorithm (Northern Hemisphere)

BYU – Quikscat backscatter product (Northern /Southern Hemisphere)

Polar Ice Prediction System (24, 48, 72, 120 hour sea ice forecasts)

Web page at http:/www.natice.noaa.gov/science

## RELATED PROJECTS

### *Operational Modeling of the Marginal Ice Zone*

ONR grant N00014-00-C-0194, "Sea Ice Model for the Marginal Ice Zone to be used by NIC", Max Coon, PI, NWRA. NWRA and Leif Toudal of DTU are carrying out much of the model development.

NRL grant number N00173-01-MP-00093, "Arctic Sea Ice Field Validation Campaign", Son Nghiem, PI, Jet Propulsion Laboratory. Several NIC personnel will assist in sea ice measurements aboard the USCGC Healy to support QUIKSCAT validation and to obtain data for validation of MIZMO.

### *Data Assimilation*

W. Meier will continue data assimilation research at his new position at the U.S. Naval Academy. He is co-PI on a proposal that has been funded to further test data assimilation methods in sea ice models of varying complexity; this will help determine an optimum model/observation combination for data assimilation. He will also be participating in another proposal to produce a twenty-five year assimilated ice motion product; this will provide baseline climatology for assimilated products. He will also continue to work with researchers at NPS in implementing assimilation in the final operational PIPS3.0.

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